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Multifaceted utilization of a cortical stimulator during tumor resection

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ABSTRACT

Background: Neurosurgeons use Ojemann cortical stimulators to map and localize cortical and subcortical regions of the brain to map functional areas intraoperatively to avoid resecting or damaging functional tissue. Here we describe a technique where, rather than using a separate retracting tool, a handheld Ojemann cortical stimulator was used to retract cerebral parenchyma while simultaneously stimulating descending white matter tracts to prevent accidental damage to white matter tracts involved with motor function.
Case description: A 48-year-old patient developed intractable seizures and preoperative workup showed a left frontal brain mass close to her motor region. Subdural grid electrodes were implanted to localize the patient's ictal onset zone. The electrodes were then removed and the tumor was resected along with the ictal onset zone. During the resection, the neurosurgeon (S. Vadera) successfully utilized the Ojemann cortical stimulator to stimulate descending white matter tracts to prevent accidental injury to the patient and also retract cerebral parenchyma during resection. Four weeks post-operative, the patient had made a complete recovery and had no unforeseen deficits or weaknesses.
Conclusion: Here we show that the Ojemann cortical stimulator can be used as an effective retraction tool as well as a cerebral parenchyma stimulator, effectively preventing accidental injury to functional tissue while concurrently giving the neurosurgeon a free hand to perform other tasks.

1. Introduction

Cortical mapping is used to determine eloquent parts of the brain that are functionally important (e.g., language or motor) [1–5]. There are a variety of techniques used including phase reversal of somatosensory evoked potentials (SEPs), extraoperative subdural grid placement, and intraoperative functional stimulation using a stimulating device such as an Ojemann [6–8]. Alternatively, functional magnetic resonance imaging (fMRI), is noninvasive and produces relatively accurate localization of eloquent cortex [1,5].

Cortical and subcortical mapping is often done intraoperatively to locate eloquent cortex and descending fibers, thus minimizing postoperative neurological deficits during tissue resection [4,9,10]. Cortical mapping is often done to define the limits of a tumor during resection [4]. Without proper cortical localization, aggressive tumor resection near eloquent cortex can result in new functional postoperative deficits [9]. Subcortical mapping stimulation has been used to map descending language [11] and motor pathways [12], and has also been done during tumor resection to prevent damage to these descending fibers [10]. However, subcortical mapping has not been as complete as cortical mapping, though there has been subcortical mapping done recently with an ultrasonic aspirator [13]. Regardless, preventing accidental injury to these descending pathways is crucial.

Brain retractors have been used during procedures like tumor resection and cortical mapping, to provide better visualization, increased articulations and degrees of freedom, greater stability, and less trauma during retraction [14]. Here we present an operative technique in which an Ojemann Cortical Stimulator was used to simultaneously 1) retract subcortical tissue during tumor resection, and 2) provide electrical stimulation that identified functional subcortical tissue during a resection. In other words, the Ojemann Cortical Stimulator functioned as both a white matter tract stimulation device and as a handheld brain retractor. This technique could be useful for surgeons performing tumor resection because it allows them to perform two tasks with one hand, leaving the other one free to perform subpial aspiration.

2. Case description

2.1. Presentation

The patient was a 48-year-old female who had developed medically refractory focal epilepsy. Preoperative workup revealed a left front brain mass in close proximity to the left-sided motor strip in the supplementary motor area (SMA) (Fig. 1). Patient was discussed in a neuro-oncology and epilepsy management conference and the decision was made to treat the patient via two surgeries.

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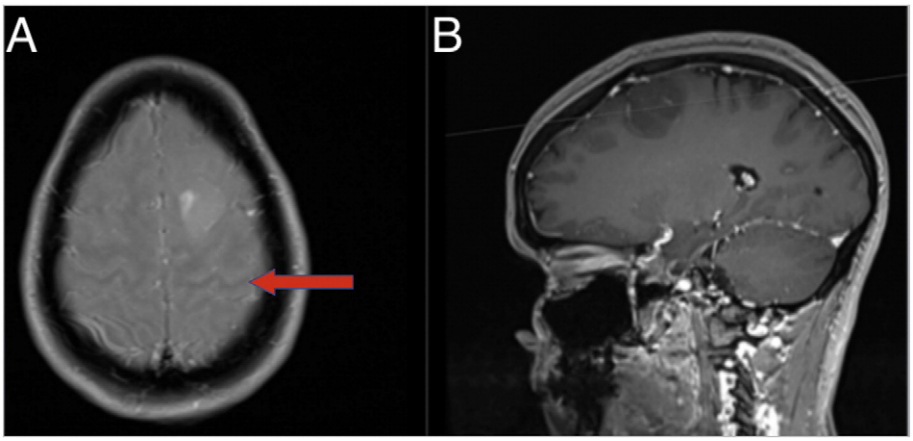

Fig. 1. Preoperative imaging implicating a tumor in the left SMA region. Panel A—axial view, Panel B—sagittal view. The arrow in Panel A indicates the central sulcus.

2.2. Treatment

First, subdural grid electrodes would be implanted to localize the patient's epileptogenic zone (EZ) and for motor mapping (Fig. 2). Second, a procedure would be done to remove the subdural grids and resect the left frontal mass. The patient tolerated the initial implantation procedure and was admitted for seizure monitoring. She also underwent extraoperative functional mapping to assess where her ictal onset zone was in relation to the motor strip.

During the second operation, the tumor, motor region, and ictal onset zone were mapped onto the patient. Baseline stimulation values were obtained by placing the Ojemann stimulator onto the motor cortex and observing subsequent motor firing. When these baseline values were obtained, the posterior margin of the tumor was resected by utilizing the Ojemann cortical stimulator as an anterior retractor of tumor tissue with simultaneous stimulation of deep white descending tracts (Fig. 3). This novel technique ensured no descending white matter motor fiber tracts were damaged, and also left the other hand of the surgeon (S. Vadera) free to perform subpial aspiration along the posterior and inferior margins of the tumor.

The ictal onset zone was also identified along two contacts mesial to the tumor and these were resected along with the tumor. The tumor was located in the patient's left SMA region.

2.3. Post-operative course

As expected, she awoke with right-sided arm and leg weakness that resolved over 4 weeks with physical therapy.

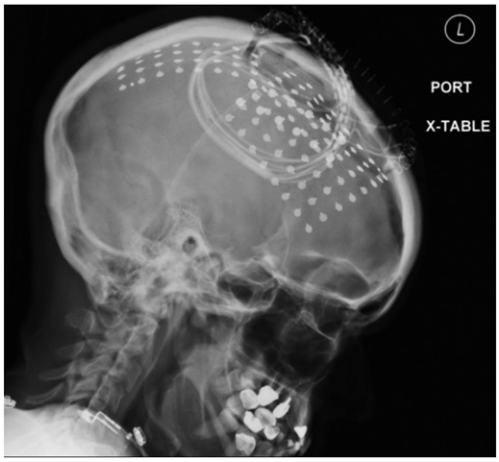

Fig. 2. Subdural grid implanted over the patient's left hemisphere.

3. Discussion

Here we describe a case where an Ojemann cortical stimulator was used to retract cerebral parenchyma as well as stimulate the deep subcortical tracts in a patient with intractable seizures. There were two main advantages to using the Ojemann cortical stimulator to retract and stimulate: 1) the stimulator retracted tissue while simultaneously providing continuous stimulation to the deeper white matter tracts, ensuring that the white matter tracts were safe to be resected, and 2) using the stimulator to perform multiple functions allowed the surgeon (S. Vadera) to have a free hand to perform subpial aspiration.

We hypothesize that using the Ojemann cortical stimulator as a handheld retractor would allow for better extent of tumor resection because the surgeon can see where functional white matter tissue is in real-time. A past study that involved tumor resection in the SMA region separated the procedures into distinct and discrete steps, where stimulation and mapping of cerebral parenchyma was done in its entirety before and after resection, but not during [15]. In contrast, the procedural steps are not as discrete with our technique, as stimulation was also done concurrently with the resection. The surgeon has the ability to see if the retracted tissue is functional in real-time, and adjust the extent of resection accordingly. Additionally, functional mapping-guided resection of tumors near eloquent tissue has been shown to improve long-term survival with certain tumors [16], and it is possible that using the cortical stimulator concurrently with resection could impact that survival rate. Additional research is needed to test the validity of this hypothesis.

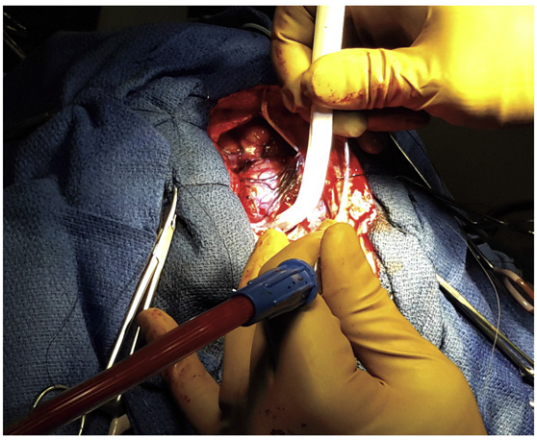

Fig. 3. The image shows the surgeon (S. Vadera) utilizing the Ojemann cortical stimulator to stimulate and retract while using his free hand for subpial aspiration. The tumor is being retracted anteriorly protecting the motor strip and underlying white matter.

While we report a successful case where the patient had a full recovery with no deficits, additional research is required to definitively show whether this is indeed a viable technique that may be used during tumor resection. We anticipate that this technique would be most useful when resecting tumors involved in subcortical tissue where there is a concern for injury to white matter tracts associated with functional tissue.

4. Conclusion

The Ojemann cortical stimulator is an effective tool that was conventionally used to stimulate cortical and subcortical tissue for localization and mapping purposes. Here we show that the Ojemann cortical stimulator can also be used as a retraction tool, effectively increasing its functionality and giving the neurosurgeon a free hand to subpial aspiration.

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